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Current energy usage and sustainable energy in Malaysia: A review

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ABSTRACT

Malaysia has a good mix of energy resources like oil, natural gas, coal and renewable energies such as biomass, solar and hydro. In spite of this plenty of resources, the country is dependent on fossil fuel for industrial and transportation sector. In 2009, 94.5% of electricity is generated by using fossil fuel such as natural gas, coal, diesel oil and fuel oil. Until now, Malaysia stills a net energy exporter. Concerns about energy security, the fluctuation of crude oil price and climate change are driving significant changes in how energy and electricity specifically, is generated, transmitted and consumed in Malaysia. In this regard, renewable energy resources are becoming attractive for sustainable energy development in Malaysia. There is because renewable sources of energy are abundant in Malaysia, the significant ones being biomass and solar. This article presents a review of present energy situation and energy policies for the energy sector in Malaysia. Investigation of various renewable energy and examine the energy and environmental issues associated with this energy. The review of current usage of renewable energy sources and also its potential implementation are evaluated to provide solution for the national.

Contents

1. Introduction

Energy is required in almost our daily life including agriculture, transportation, telecommunication and industrial activities that influence the economic growth. The economic growth is measure by gross domestic product (GDP) and in Malaysia, GDP is correlates almost exactly with the energy consumption of the country. The growth in the economy in Malaysia is dependent on an uninterrupted supply of energy. Hence, it implies that any conservation policies or shock to energy supply will have an adverse effect on economic growth. In 2000, the transport sector is the main user of energy at Malaysia. However, in 2009 the industrial sector accounted for 43% of the total energy consumed, surpassing the transport sector at 36%. For the industrial sector, the mains form energy used were gas and electricity. Electricity energy sector in Malaysia is forecasted growth, the demand for electricity is expected to increase from 91,539 GWh in year 2007 to 108,732 GWh in year 2011 [1–4]. Accordingly, it is projected that by 2020, the final energy demand in Malaysia will reach 116 Mtoe based on an annual growth rate of 8.1% [5]. With the rapid economic development, Malaysia needs more and more resources to support the industrial development and to enhance the productivity of capital, labor and other factors to production.

In Malaysia, electricity sector is dependent on fossil fuel sources. In 2009, almost 94.5% of electricity is generated by using fossil fuel

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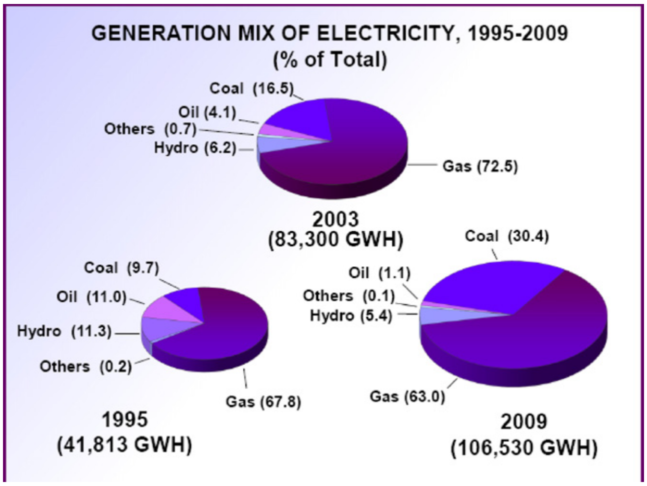


Fig. 1. Malaysia generation mix of electricity for years 1995, 2003 and 2009.

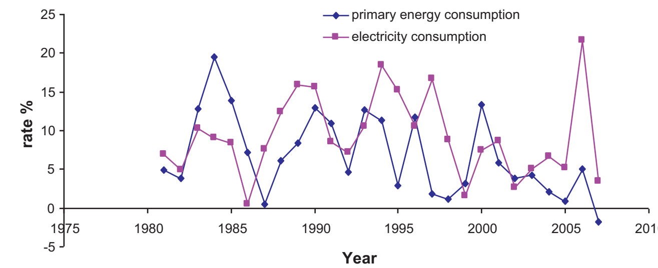


Fig. 2. Rate of primary energy and electricity consumption in Malaysia by year.

such as natural gas, coal, and oil. The balance was generated by hydroelectric [6]. Fig. 1 shows the Malaysia generation mix of electricity for year 1995, 2003 and 2009 [1]. It seem that fossil fuel dominate the majority energy generation in Malaysia. The generation of electricity in Malaysia climbs almost 154% in 14 years from 1995 to 2009. Among of them, coal shows an increasing percentage in Malaysia generation of electricity from 9.7% (1995) to 30.4% (2009). The increase is due to opening new coal fired power stations and also government licensing of independent power producer (IPP). The development of alternative energy sources such as hydroelectric and coal industries is plan to ensure the demanding of electricity energy for year 2015 [7].

Table 1 shows the total energy production and consumption from year 2000 until 2008. Among the production of renewable, hydroelectric is the highest in 2000 reaching 7.34 billion kWh. It should be noted that Malaysia export electricity, and in 2007, 2268 billion kWh were sold for export. This amount slightly reduced about 2.5% from previous year, which is 2326 billion kWh sold for export.

Malaysia's geographic location has several advantages for extensive use of most of renewable energy sources, with total a landmass of 329,845 km^2. The two distinct parts of Malaysia separated from each other by the South China Sea share a largely similar landscape in that both west and east Malaysia feature coastal plains rising to often densely forested hills and mountains. Malaysia is entirely equatorial, which is characterized by the annual Southwest (April–October) and Northwest (October–February) monsoons. The ambient temperature remains uniformly high throughout the year between 27 °C and 33 °C, with an average daily solar radiation of 4500 kWh/m^2 and average daily sunshine duration of about 12 h. The abundance of solar radiation in Malaysia makes it highly potential for solar power generation [8].

2. Energy use in Malaysia

The energy demand of Malaysia in 2009 is 16,132 MW, compared to 10 years before the demand of electricity is just 9690 MW [1]. The rising in electricity demand from 1999 is about 66.5%. This rapid increase in demand is due to the high economic development rate of Malaysia. In 2009 the population of Malaysian is 25.4 million people, by the year 2020 almost 75% will live in urban areas and the population will have almost doubled since 1980 [10]. Percentage of population rate is slow, which is less than 3% annually. While the rate of electricity consumption up to 19.5% in the early of 80an.

In the last 28 years, primary energy consumption has increased by an average of 6.8% and electricity consumption by 9.2% annually. Fig. 2 shows the same pattern of primary energy consumption and electricity consumption in Malaysia.

In 2007, primary energy production and consumption reached 3.5 and 2.4 Quadrillion-Btu, respectively (Table 1). Malaysia's Petroleum Production and Consumption, 1980–2009 is presented in Fig. 3.

Total petroleum production in 2009, 693,730 barrels per day (bbl/d). During 2009, Malaysia consumed an estimated 536,000 bbl/d and had net exports of about 157,730 bbl/d. Petronas and its various PSC (Production Sharing Contracts) such as ExxonMobil, Shell, Chevron and BP are most active exploring offshore areas. Since 2002, the focus has been on deep water fields on the eastern continental shelf that pose high operating costs and require substantial technical expertise. Petronas announced in January 2009 that 7 new oil field had come online in 2008, making for a total of 68 producing oil fields. As we know Malaysia blessed with petroleum resources, but the amount is relatively small in the international area. Malaysia's oil reserves of about 5.5 billion barrels are relatively small compared to those in Saudi Arabia (260

Table 1
Primary energy consumption of Malaysia during 2000–2008.

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total electricity capacity (million kW)	13.762	14.813	15.671	20.119	24.432	23.333	20.878	20.878	NA
Total electricity consumption (billion kWh)	59.983	65.113	66.893	70.269	75.009	78.915	95.95	99.247	NA
Total renewable consumption	7.34	6.372	5.249	5.694	5.77	5.136	6.38	6.426	6.706
Hydroelectricity consumption	7.34	6.371	5.248	5.693	5.769	5.135	6.379	6.425	6.705
Non-hydroelectric	0	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Geothermal	0	0	0	0	0	0	0	0	0
Wind	0	0	0	0	0	0	0	0	0
Solar, tide and wave	0	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Total electricity generation	65.428	67.424	70.01	74.01	78.218	82.324	99.51	103.181	106.691
Total conventional generation	58.088	61.052	64.761	68.316	72.448	77.188	93.13	96.755	99.985
Total renewable generation	7.34	6.372	5.249	5.694	5.77	5.136	6.38	6.426	6.706
Total primary energy production (Quadrillion-Btu)	3.31319	3.33962	3.43189	3.65955	3.77261	3.60459	3.58331	3.5172	
Total primary energy consumption (Quadrillion-Btu)	1.97671	2.09382	2.17531	2.26785	2.31652	2.33821	2.45683	2.41255	

Source: [9].

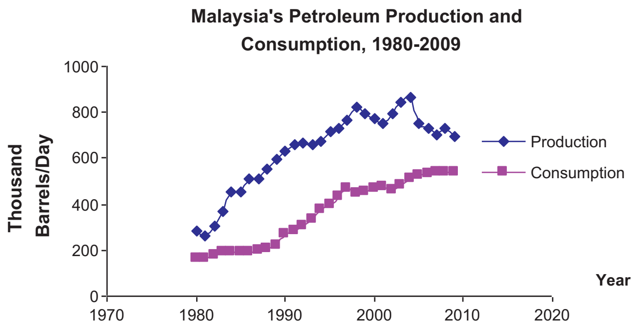


Fig. 3. Malaysia's petroleum production and consumption, 1980–2009.

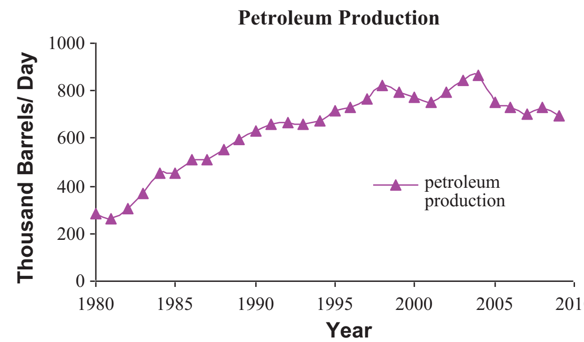


Fig. 6. Petroleum production.

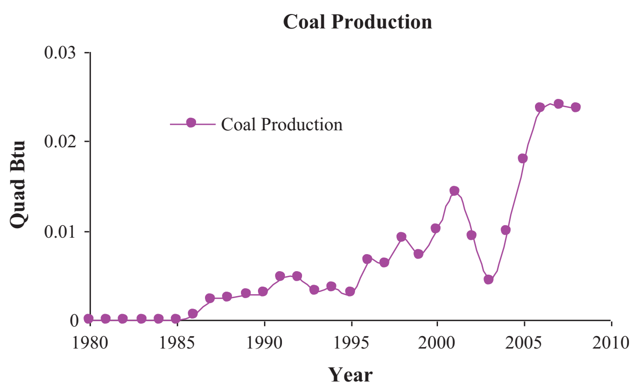


Fig. 4. Coal production.

billion barrels), Iran (138 billion barrels) and Iraq (115 billion barrels). Likewise for gas, Malaysia's gas reserves of 88 trillion cubic feet (tcf) are much smaller in comparison with Russia (1680 tcf), Iran (1046 tcf) and Qatar (900 tcf).

Figs. 4–6 show the three type of primary energy production in Malaysia. The production of petroleum is decreasing. The petroleum production reached its highest level of 861.8 thousand barrel per day in 2004. However, this development could not be maintained in subsequent years, and production of petroleum entered into a regression period. Oil import is predicted to take place by 2013 and reach 45 Mtoe in 2030 [11]. Contrast to natural gas which is goes up in production. In 2008 the production of natural gas goes to 2023.55 billion cubic feet from only 56 billion cubic feet in 1980. Coal import will increase following governmental policy of intensifying its use for power generation [11]. As for coal, the consumption increased from 0.096 to 0.387 Quadrillion-Btu between 2000 and 2008 [9] with the bulk of it consumed in power generation, mainly driven by the Malaysian governmental policy of shifting to coal in order to reduce high dependence of this sector to natural gas. In spite of this, in the long term fossil fuels are finite and they are depleting. As fossil fuels deplete and become more expensive, countries will be competing for the reserves that are left. Right now, we should search and look to other forms of energy in particular renewable energy sources.

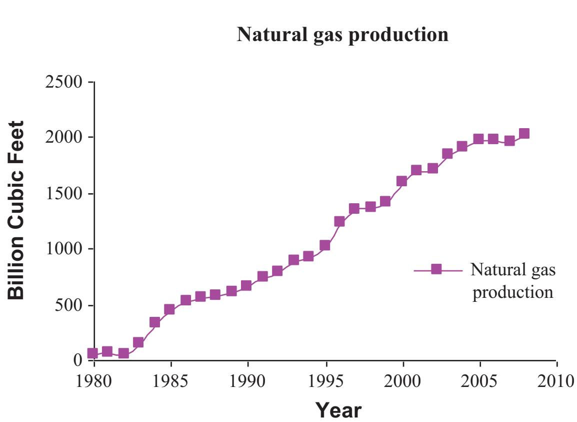


Fig. 5. Natural gas production.

The crucial challenges of Malaysia power sector are sustainability, security and reliability of energy supply from energy resources, which is mix of non-renewable and renewable energy for long term sustainable development. Today, the world is more circumspect, Green Technology application is seen as one of the sensible solutions which are being adopted by many countries around the world to address the issues of energy and environment simultaneously. Green Technology is a technology that allows us to progress more rapidly but at the same time minimizes the negative impact to the environment. Hence, Malaysia need to start encourages the usage of alternative energy for less depending on fossil fuel production.

3. Renewable energy in Malaysia

In 1981, the Government adopted the four-fuel strategy, complementing the national depletion policy, aimed at ensuring reliability and security of supply. The depletion of fossil fuels will require Malaysia to use more sources of renewable energy for the sustainability of its development. The National Biofuel Policy encourages the use of biofuels in line with the nation's Five-Fuel Diversification Policy. The main objective of National Biofuel Policy is to reduce the depending on fossil fuel that associated with environmental problem such as the greenhouse gas emission. On April 2009, Malaysia formulated the National Green Technology Policy to reflect that Malaysia's seriousness in driving the message that 'clean and green' is the way forward towards creating an economy that is based on sustainable solutions. It will also be the basis for all Malaysians to enjoy an improved quality of life. The government wants to promote green technology usage to push for economic growth in the new economic model [12]. This was further emphasized where efforts in the utilization of renewable energy (RE) resources and efficient use of energy were further promoted. Table 2 shows the Green Technology Financing Scheme in Malaysia.

Malaysia has introduced the Green Technology Policy that will facilitate the development of knowledge society, which would encourage us to embrace a sustainable and better way of living on 9th April 2009. In that portfolio the use of renewable energy is satisfy the criteria of green energy. Renewable energy resources available in Malaysia are biomass, solar, mini-hydropower, municipal waste and biogas. Among them, the Ministry of Energy, Green Technology and Water state that the huge potential renewable energy at Malaysia is biomass and solar energy. Biomass resources

Table 2
Green technology financing scheme.

Descriptions	Producer	User
Size	Maximum RM 50 billion per company	Maximum RM 10 million per company
Tenure	15 years	10 years
Criteria for eligibility	Malaysian-owned company (>51% Malaysian equity)	Malaysian-owned company (>70% Malaysian equity)
Financial institution	Commercial bank, Islamic bank and Development Financial Institutes	
Government incentive	Interest subsidy of 2% and government guarantee of 60% of amount borrowed	

Source: [13].

Table 3
Land resource requirement to produce 1 billion kWh/year of electricity.

Electrical energy technology	Land required (ha)
Hydroelectric power	75,000
Biomass	200,000
Wind power	9500
Photovoltaic	2800
Nuclear	30

Source: [15].

such as palm oil residues, wood residues, and rice husks can be used for the heat and electricity generation (co-generation). In this case of solar power, the climatic conditions in Malaysia are favorable for the development of solar energy due to abundant sunshine with the average daily solar insulation is 5.5 kWm^2, equivalent to 15 MJ/m^2. The important component needs to consider while implement all these type of renewable energy is land resource requirement. RE resources utilizes more land compared to fossil fuel in the process of generated electricity. Table 3 lists the land resource requirements for construction of renewable facilities that produce 1 billion kWh/year of electricity. Malaysia total land area 32.9 million ha [14] and 61% is natural forest and agriculture land area contain 14.9%.

The importance of RE as an enabler of strong economic growth is further reinforced in the 9th Malaysian Plan (2006–2010), coupled with an emphasis towards Energy Efficiency (EE) both on production and utilization, while meeting environmental objectives. Currently, there are a number of RE projects in Malaysia, which is Small Renewable Energy Power Programme (SREP), Malaysia Building Integrated Photovoltaic (MBIPV) Systems also known as SURIA 1000 program, PTM-UNDP Biogen Project and Hybrid Solar PV Systems for rural electrification. Small Renewable Energy Program (SREP) was launched in May 2001. Under this program, small power generating plants which utilizes renewable energy can apply to sell electricity to Tenaga Nasional Berhad (TNB). Up to now, the total energy generating under SREP is 241.65 MW and only 43.5 MW is connected to the system grid as presented in Table 4. Many of the approved renewable power plants under SREP scheme use biomass, wood waste and rice husk as a source of energy. According to [16], 185 projects related to the development of technologies focusing on harnessing energy from resources such as solar, hydro, wind and tidal waves costing RM 158 million have been carried out. Related to this, Malaysia develop a renewable energy technology roadmap in five focus areas comprising biomass, solar, wind, micro hydro and tidal power.

Table 4
Project under SREP program.

Fuel type	Company	Export capacity (MW)
Biomass (EFB & MSW)	TSB Bioenergy	10
	Kina Biopower	10
	Seguntor Energy	10
	Recycle Energy	5.5
Biogas	Jana Landfill	2
Mini hydro	Esajadi Power	2
	AMDB Berhad	4

Source: [17].

Table 5
Tariff structure for FiT implementation at Malaysia (Proposed for 2011).

RE type	Tariff (RM/kWh)	Duration (Year)
Solar PV		
<4 kW	1.23	21
>4 kW<24 kW	1.20	
>24 kW<72 kW	1.18	
>72 kW<1000 kW	1.14	
>1 MW<10 MW	0.95	
>10 MW<30 MW	0.85	
Bonus for rooftop	0.26	
Bonus for BIPV	0.25	
Bonus for local modules	0.03	
Bonus for local inverters	0.01	
Biomass		
<10 MW	0.31	16
>10 MW<20 MW	0.29	
>20 MW<30 MW	0.27	
Bonus for gasification	0.02	
Bonus for steam generation >14% effic.	0.01	
Bonus for local manufacture	0.01	
Bonus for municipal solid waste	0.10	
Biogas		
<4 MW	0.32	16
>4 MW<10 MW	0.30	
>10 MW<30 MW	0.28	
Bonus for gas engine >40% effic.	0.02	
Bonus for local manufacture	0.01	
Bonus for landfill or seweage gas	0.08	
Mini hydro		
<10 MW	0.24	21
>10 MW<30 MW	0.23	

By 2015, the estimated potential for electricity from renewable sources such as biomass and biogas is 330 MW and 100 MW, respectively. For the same period of time, mini hydro is estimated to have a power generation capacity of 290 MW, while the solid waste is about 200 MW [18]. Since, Malaysia's total energy demand in 2020 is estimated [19] to be about 100 GW, renewable energy sources provided by solar PV, biomass and hydroelectricity could, with a significant investment, supply about 20% of this energy assuming that none of its was exported [20].

However, according to [21], renewable energy development in Malaysia is quite slow due to mainly insufficient commitment by the government. But, on May 2010, Minister of Energy, Green Technology and Water made an official announcement regarding the National Renewable Energy Policy. The Parliament will legislate the implementation of the feed in tariff (FiT) for renewable energies. The FiT is a mechanism that priorities electricity generated from indigenous renewable energy resources to be purchased by power utilities at a fixed premium price and for a specific duration. And this mechanism is expected to start by 2011. Table 5 illustrates the tariff structure for FiT implementation in the way to attractive the companies and individual to invest. Hopefully, the implementation this FiT mechanism will accelerate renewable energies deployment and reducing the carbon emission. On June, 2010, the government announced the National Renewable Energy Policy and Action Plan with a goal of increasing renewable energy from 1% to 5.5% of electricity supply by 2015. Table 6 shows the cumulative Quato on RE Capacity in Malaysia [22].

Table 6
Cumulative Quato on RE capacity.

Year	Biomass (MW)	Biogas (MW)	Mini hydro (MW)	Solar PV (MW)	Solid waste (MW)	Total (MW)
2011	110	20	60	9	20	219
2012	150	35	110	20	50	365
2013	200	50	170	33	90	543
2014	260	75	230	48	140	753
2015	330	100	290	65	200	985
2016	410	125	350	84	240	1209
2017	500	155	400	105	280	1440
2018	600	185	440	129	310	1664
2019	700	215	470	157	340	1882
2020	800	240	490	190	360	2080

3.1. Biomass energy

Malaysia is bestowed with significant amount of biomass resources. These make the biomass most promising option, compare to others various source of renewable energy at Malaysia. Malaysia total land area is 32.90 million ha. About 61% of the area is still natural forest, while 14.9% is use for agriculture activities. The five major sectors that wastes contribute to the biomass energy in Malaysia are oil palm cultivation (43.67%), forestry (wood) (30.56%) rubber cultivation, animal farming and urban wastes. However, among of these palm oil wastes including biogas are the largest source of biomass in the country.

Malaysia is the world second largest producer and exporter of crude palm oil. The development of palm oil plantation increased substantially from 400 ha in 1920 to about 4.69 million ha in 2009, and is projected to expand to 5.2 million ha in 2020 [23]. The expansion of the palm oil industry is expected to generate huge quantities of biomass wastes that could be used as a potential source of renewable energy. This because, 1 ha of palm oil plantation can produce about 50–70 tonnes of biomass residues [24]. At, present, there are about 417 palm oil mills found in the country, which dispose a substantial amount of biomass waste in the form of empty fruit bunches (EFB), mesocarp fibers and shells annually.

Fig. 7 shows the cultivated area for oil palm in Malaysia (divided into three categories, i.e. Peninsular Malaysia, Sabah and Sarawak) within 34 years. The total oil palm planted area in the country increased by 4.5% to 4.69 million ha in 2009 [25]. In Sabah and Sarawak, the drastic increase in the 1990s can be attributed to the government policy in the intensification of palm oil industries in East Malaysia [26]. Malaysia produces about 15 million metric tonnes of palm oil per year. One tonne produces about 414 kg of biodiesel. With a caloric value of about 40,000 kJ/kg, this results in a total energy supply of about 7.8 GW/year from palm oil.

While the total energy available from residues and landfill gas has been estimated as 3.1 GW [27]. Major agriculture crop in Malaysia are oil palm (43.67%), rubber (30.56%), rice (12.68%), cocoa (6.75%) and coconut (6.34%). These provide Malaysia huge of biomass resources. In fact, government of Malaysia has announced the 5th Fuel Policy that states "To supplement the conventional supply of energy, new sources such as renewable energy will be encouraged and biomass resources such as oil palm and wood waste as well as rice husks, will be used on a wider basis mainly for electricity generation" [28]. Currently, residue from agriculture crops like paddy, rubber and sugar are use as fuel for generation of electricity in Malaysia using the cogeneration system. However, the percentage of using this residue for electricity generation is still low. Biomass residues are the main source of energy input to the mills using cogeneration system. It has been estimated the total biomass energy potential is equivalent to 2-3% of total power production in the country [29]. Report from [30], about 14 mills already used agriculture waste for energy demand, both for steam and electricity with total capacity amount 1567.2 MW. The increasing amount of paddy production make highly potential in CHP technology to convert the paddy husk residue for energy purpose. Around 20% of paddy is husk, rice husk in turn contains 16–22% ash, and 90–96% of the ash is composed of silica (silicon dioxide, SiO_2). According to [31], by 2020 Malaysia will produce 768,290 tonnes of rice husk. As refer to [32], 1.5 kg of rice husk can generate 1 kWh, this mean by 2020 Malaysia can produce 512 TWh using rice husk residue. Some example of cogeneration project based on rice husk installed in Pendang Kedah Darulaman, which uses a steam boiler, 6.5 tonnes/h, 30 bar, saturated, connected to a 450 kW back pressure turbine and heat exchanger [33]. Electricity produces use for their owned consumption. Other example of rice husk project cogeneration that connected to system grid is installed at Titi Serong Rice Mill [34].

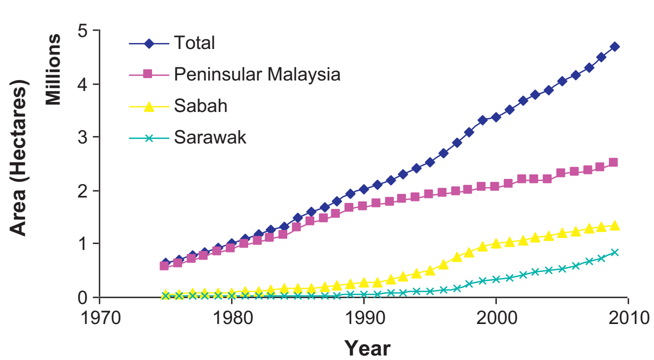


Fig. 7. Cultivated areas for oil palm in Malaysia, 1975–2009.

In Malaysia, the annual production of sugarcane bagasse reaches a number of million tonnes [35]. Nearly 30% of that number will turn into bagasse when it is crushed in a sugar factory [36]. Sugarcane baggase is the fibrous waste that remains after recovery of sugar juice via crushing and extraction. A ton of bagasse (50% mill-wet basis) is equal to 1.6 barrels of fuel oil on energy basis. The total of sugarcane energy content on dry basis, excluding ash (around 2–3% of weight) can be divided into three main parts. Malaysia produces 274,620 tonnes of sugarcane for 2009, with a moisture content of 50%. This means we can get 150,000 tonnes of dry bagasse annually. The caloric value for dry bagasse comes to be 17.33 MJ/kg, which make to total energy potential of 0.421 million boe per year. At the time, all the bagasse is being used as boiler fuels in sugar mills operating in the country. Most agriculture crops in Malaysia can be used to generate electricity. If all crops are fully utilize can help reduce the dependency on fossil fuel sources.

3.2. Solar energy

Solar energy, a green and renewable energy source, is the conversion of sunlight into electricity via the use of solar cell installed in a solar panel. This system called photovoltaic cells. Photovoltaic cells produce electricity when sunlight excited electrons in the cells. Malaysia climatic condition, which is having sunshine throughout the year make it highly suitable for the development of solar energy. The annual average daily solar irradiations for Malaysia were from 4.21 kWh/m^2 to 5.56 kWh/m^2. The highest solar radiation was estimated at 6.8 kWh/m^2 in August and November while the lowest was 0.61 kWh/m^2 in December [37]. Although PV system has tremendous potential, especially for remote areas in Malaysia, the cost of PV panels and technology is still too expensive for mass power generation [38]. The effort and initiative of government also still lower if compared to others countries that have less potential in solar electricity generation [39]. The cost is 20 times higher compared to the cost generated by conventional plants [40].

Table 7
Status program offered under MBIPV project.

MBIPV program	Target capacity (kWp)	Awarded capacity (kWp)	Commissioned capacity (kWp)
Showcase	125	140	140
Demonstration	205	214	197
SURIA1000	1215	885	146
Total	1545	1239	483

Source: [41].

In order to reduce the cost of PV system, Malaysia Energy Center (PTM) embarked on a project named Malaysian Building Integrated Photovoltaic (MBIPV). Under this project, three main programs are offered to enhance the penetration of PV in local market. Table 7 lists down the status of program are offer under MBIPV.

The showcase and demonstration project purposely for provide an example for public or industry regarding the PV system. Under SURIA 1000 program, electricity customers can bid price rebates on PV systems under MPIPV project. The successful applicants received the discount of an average, 53% the PV system. As of 31 December 2009, the total capacity BIPV system installed and commissioned are 1084.01 kWp. Table 8 shows the amount of PV system installation at Malaysia from 2005 until now 2009 under SURIA 1000 program. Currently, all MBIPV incentives have been taken and no longer available. Study by Ref. [42], state that even government provided a subsidy up to 70%, the owners of PV systems still not be able to make any financial return on their investment. But, may be offering higher tariff of PV electricity can promote the installation of PV system.

The country has so far attracted RM 10 billion in investments in the fast growing photovoltaic (PV) or solar energy industry [44]. On green technology, the ministry has started to increase the generation of electricity from renewable energy sources like mini hydro in Kundasang and Hulu Langat, biomass in Semenyih and Sandakan and the biogas in Seri Kembangan and solar sources under the Suria 100 program. Its target for 2010 is for 65 MW electricity that would be generated from renewable source and 2013 kW from solar sources. Currently, a number of projects are on progress regarding the solar energy. The project listing under the Ministry Minister of Energy, Green Technology and Water are 100 kWp demonstration photovoltaic project, photovoltaic grid connected roof solar 3 kW and hybrid diesel solar PV [45]. Perak state will host cutting edge photovoltaic (PV) cell production facilities involving an initial FDI of US $250 million (RM 877 million) to produce 100 MW of PV cells per annum by 2011. While Terengganu government spends RM 100,000 to install generated 1980 W of energy to supply for seven houses and there will be more project install in Malaysia. By 2013, Melaka will generate 1400 MW high efficiency solar cells annually [46].

Beyond 2020, it is predicted that solar energy will surpass all other forms of renewable energies for Malaysia. Solar photovoltaic (PV) is estimated to have a cumulative capacity of 55 MW in 2015.

Table 8
PV system installation under Suria 1000 program.

Building type	Year				
	2005	2006	2007	2008	2009
Commercial	1	0	6	3	8
Industrial	0	0	0	0	0
Residential	1	0	3	24	19
School	0	0	0	0	0

Source: [43].

Table 9
List of Malaysia hydropower.

Peninsular Malaysia (MW)		Sarawak/Sabah (MW)	
Nenggiri	450	Murun	900
Lebir	272	Baleh	950
Galas	108	Pelagus	770
Ulu Terengganu	516	Ligawa	164
Tekai	156		
Telom Dam	91		
Maran	109		

Source: [50].

3.3. Hydropower

Malaysia country can be found abundance of water. The average annual rainfall is about 3540 mm per annum. When it is harnessed for hydroelectric energy, it can power the lighting for entire cities. Hydroelectricity contributes about 2.8% (2000 MW) of Malaysia's total electricity requirements and providing 6% of world energy supply [47]. Tenaga Nasional Berhad operates three hydroelectric schemes in Peninsular with an installed generating capacity of 1911 MW. There are Sungai Perak, Terengganu and Cameroon Highland hydroelectric schemes with 21 dams in operation. Table 9 lists the operating hydropower in Malaysia. The country hydropower plants is control by Tenaga Nasional Berhad The contribution of hydropower for generation of electricity is reducing by 1.1% from year 2006 to year 2007. Hydroelectric plants however require considerable land for their water storage reservoirs. An average of 75,000 hectares (ha) of reservoir land area and 14 trillion L of water are required per 1 billion kWh/year produced [48]. Currently, the biggest hydropower project in Malaysia is the on going Bakun hydropower project having a capacity of 2400 MW, located at Sarawak and will be complete and delivery on the year of 2011. The Bakun hydroelectric project involved the construction of a 205 m high rock filled concrete dam creating a reservoir of 695 km^2. These Bakun hydropower will serve the electricity to the peninsular of Malaysia through the undersea cables that will be ready on 2015 for first phase cables and 2017 for the second phase [49].

3.4. Wind and tidal energy

The potential for wind energy generation in Malaysia depend on the availability of wind resource that varies with location. Understanding the site specific nature of wind is a crucial step in planning wind energy project. Detailed knowledge of wind on site is needed to estimate the performance of wind energy project. Average wind speeds are low in Malaysia and harnessing wind energy is only practical on remote islands or east cost states of peninsular Malaysia where the wind may reach 30 knots or more during periods of strong surges of cold air from the north. 30 knots is equivalent to about 15.4 m/s, which is about 55 km/h. However, application of wind energy at Malaysia can be used widely if the turbine can operate in country average wind speed which is 3–5 m/s. The study done by Ref. [51], were successful produce the electricity that suitable with wind condition of Malaysia, classified as low wind speed wind turbine.

The northwest coast of Sabah and Sarawak region also potential to application of wind energy due to strength wind that reach 20 knot or more. Due to maximum wind can be obtained during monsoon season which is between Octobers to March, the hybrid system of wind energy is feasible to compliment electricity supply during monsoon season. The first wind farm in Malaysia was set up on Terumbu Layang-Layang Island, Sabah. A Universiti Kebangsaan Malaysia study in 2005 has shown that the use of 150 kW turbine on the island has shown a good degree of success. Study done by

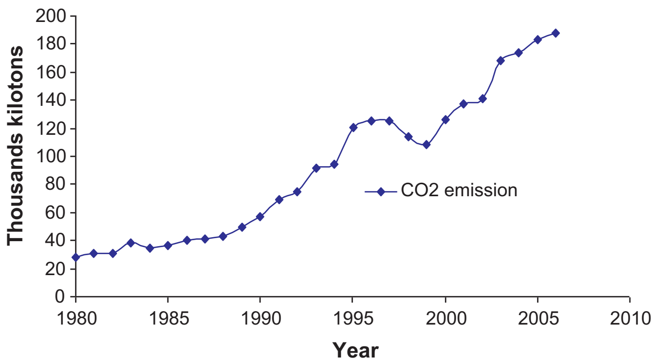


Fig. 8. CO_2 emission at Malaysia, 1980–2006.

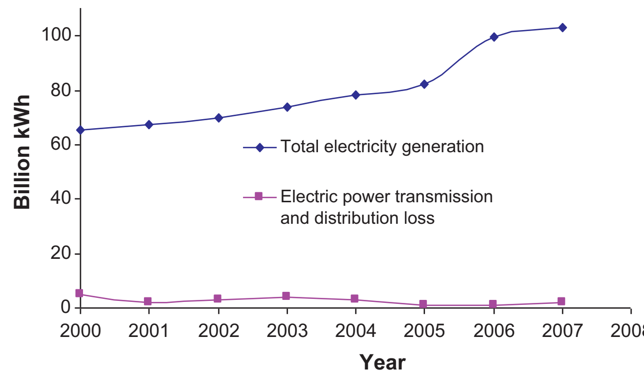


Fig. 9. Electricity generation and the power losses.

Ref. [52], state that Terumbu Layang-Layang Island has the largest wind energy potential compared to other places in Malaysia.

Tidal energy is also promising renewable energy source available in Malaysia. Until recently, a preliminary study was carried out to explore the potential of ocean energy for electricity generation in Malaysia [53]. Study by Ref. [54], identified that Pulau Jambangan, Kota Belud and Sibu are the locations with great potential for tidal energy extraction. The total amount of electricity that can be generated on those locations is about 14.5 GWh/year.

4. Environment impact of energy use in Malaysia

Malaysia also facing the same situations likes others countries in energy industries regarding the global environment issue, fluctuation of oil price and also the depleting of fossil fuel. Recently, air pollution is becoming a great environmental concern in Malaysia. Air pollution from energy utilization in this country is due to the combustion of coal, lignite, petroleum, natural gas, wood, and agricultural and animal wastes. All these basic fuels produce by product such as CO_2, SO_2 and NO_X. In Malaysia, the CO_2 emissions totaled about 118 million tonnes in 2006. The amount of carbon emission per person was about 7.2 tonnes. Fig. 8 shows the emission of CO_2 at Malaysia for 26 years from 1980 until 2006. Owing mainly to the rapid growth of primary energy consumption, CO_2 emissions in particular have increased rapidly in 1990an until now. The evidence also suggests that degradation of the environment precedes economic growth. In Malaysia, an increase in pollution level induces economic expansion is not surprising given that much energy inputs have been consumed in the production to promote heavy industry [55].

The Kyoto Protocol to the UNFCC is an amendment to the international treaty signed in1992 on climate change, assigning mandatory emission limitations for the reduction of greenhouse gas emissions to the signatory nations. The objective of the protocol is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Malaysia is a party to the UNFCC and has ratified the Kyoto Protocol. Malaysia ratified Kyoto Protocol on 4 September 2002. At the Copenhagen Climate Change conference, Malaysian Prime Minister Najib Razak announced that Malaysia was committed to reducing its carbon emissions by offering 'credible cut' of up to 40% by 2020. Start this year, Malaysia need to step down it emissions about 4% every year. Fossil fuel was main contribution of greenhouse gases at the same time affect the plant growth. Also according to [56], utilization of fossil energy is causing major local environmental and health concern. Fossil fuels play main role in acidification and global climate change because this burning fuel produce CO_2, SO_2 and NO_X [57]. Study found by Ref. [58], in Malaysia the electricity generation sectors have produced huge emission from their power plants. This is due to effectiveness of these power plants is only about 35–40% with the remaining chemical energy converted into heat. Fig. 9 shows the pattern of electricity generation and the transmission and distribution losses between years 2000 until 2007. The unstable pattern can see for power transmission and distribution loss, while total electricity generation shows the increasing for kWh each year. Malaysia electricity generation pattern see the change in fuel mix generation were switching from fossil fuel to coal since the implementation of 5th Fuel Policy 2001. The too much reliance on coal has environmental implication. Its utilization faces major challenges as shown in Table 10 [59]. Greater dependence on coal for electricity generation as well as its pollution implications could be avoided if Malaysia switches to others sources of renewable energy like wind, photovoltaic, solar thermal and biomass [60].

Table 10
Total environment impacts of electricity generation.

Pollution emissions	1999 pollution intensity (Kt)	2000 pollution intensity (Kt)	2009 fuel mix (Kt)	2020 proposed fuel mix (Kt)
CO_2	298,339	330,529	350,559	800,519
SO_2	3159	3544	3840	3840
NO_X	2445	2616	2316	18,316

Source: [59].

5. Conclusion

The Malaysian energy sector is still heavily dependent on non-renewable fuel such as fossil fuel and natural gas as a source of energy. The main reasons to search for alternative energy are due to energy security and environment. Meanwhile, these sources will come to the end (deplete) and also harm the environment (climate change problem). A large portion of the environment impact in a society is associated with its utilization of energy resources. Malaysia need to take fast action reduce the dependent on non-renewable and start realize the potential of renewable energy such as biomass, solar and also wind source. The main stakeholder like government, institution, industry and society should discuss this issue in depth before it late in order to become a sustainable country. All strategies for accommodating the fossil fuel decline require decades to have any significant effect. The study done by [11] showed that a generally takes decades to substitute one form of primary energy and 100 years for a given source of energy to achieve 50% market penetration.

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